Formerly Utilized MED/A
Remedial Action

Radiological Survey of the Building Site 421
Watertown Arsenel, W

U.S. Dep
Assistant S
Division of Environm

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This is one of a series of reports resulting from a program initia by the Atomic Energy Commission (AEC) for determination of the of sites formerly utilized by the Manhattan Engineer District (MED AEC for work involving the handling of radioactive materials. Sin 1940's the control of over 100 sites that were no longer requir ear programs has been returned to private industry or the publ stricted use. A search of MED and AEC records indicated that, fo hese sites, documentation was insufficient to determine whether decontamination work done at the time nuclear activities ceased is ad urrent guidelines.

This report contains the results of surveys of the current radio ition of the Building Site 421, United States Arsenal Wate rtown, Massachusetts. Findings of this survey indicate there ar s involving an area of less than 6 000 cm^2 of identifiable low-level r activity on the concrete pad which is all that remains of Building The largest spot is approximately 5 000 cm^2. The other three spo cm^2 or less. The beta-gamma readings at these spots are 8.4 nin-100 cm^2, 2.2 x 10^5 dis/min-100 cm^2, 2.2 x 10^5 dis/min-100 cm x 10^4 dis/min-100 cm^2. No alpha contamination was found at ions. Gamma spectral analysis of a chip of contaminated concret of the spots indicates that the contaminant is natural uranium. amination is "fixed" in the concrete and does not present an inter

er three spots indicated an elevated direct reading with the En
ector.

Radon daughter concentrations were determined at three locatio
lding 421 pad. These were 0.00013 WL, 0.00011 WL and 0.0
ording to the Surgeon General's Guidelines found in 10 CFR 71
ghter concentrations below 0.03 WL do not require remedial
uctures other than private dwellings and schools.

Soil samples taken about the site indicate no elevated levels a
ural background levels in the soil. A gamma spectral analysis o
ple obtained from the storm sewer line near the Building 421 pad
elevated radioactivity in the sample. It was therefore felt
tamination is present in this sewer.

s radiological assessment was performed by the following Health
sonnel of the Occupational Health and Safety Division, Argonne
oratory, Argonne, Illinois: R. A. Wynveen, W. H. Smith, C
es, P. C. Gray and D. W. Reilly.

Table Pag

BUILDING SITE 421

U. S. ARSENAL WATERTOWN,

WATERTOWN, MASSACHUSETTS

INTRODUCTION

uring the Manhattan Engineer District/Atomic Energy Commission (M
ra, an area known as Building 421 was occupied on the Unite
rsenal Watertown Site. The site was used a laboratory and office
ne preparation and processing of uranium. Originally, laboratory t
as conducted at Massachusetts Institute of Technology (MIT) and in
boratory was moved to the Watertown Site. Since there are no rec
nal survey of the Building Site 421, it was decided to undertake a s
ne remaining floor pad of this building. All that is left of the Bui
a large concrete pad which had been the foundation of the buildi
rea of the pad was approximately 22 630 m^2. At the time of the s
ortion of the pad was used as a storage area for concrete caske
he area covered by these vaults was approximately 5% of the t
vailable for survey. The arsenal property east of the Main Gat
cludes the Building 421 site, is at present owned by the W
edevelopment Authority, Watertown, Massachusetts.

l

ll accessible concrete pad areas were surveyed, with the except
rea which was utilized for storage of the concrete vaults. In add
terior south wall of Building 331, since it was adjacent to Buildin
urveyed its entire length to the height of 2 meters. See Table
s 1A and 1B for locations of the areas surveyed. (All measure
riginally taken using the English system. The Standard Interna
nits are to the nearest approximation. For example, 2 inches are
m.)

mentation

our types of survey instruments were used (Table 2). An Eb
monitor, Model FM-4G, having a detection area of 325 cm^2, utilizi
ne PAC-4G-3 electronics, was used to survey the pad. A PAC
a hand-held detector, 51 cm^2 sensitive area, was used to surve
and other areas not accessible with the floor monitor. Double alum
(0.85 mg/cm^2) windows were used in both detectors. This allo
ow energy beta detection and increased instrument sensitivity. B
instruments were initially used in the beta mode. In the beta
etector responds to alpha and beta particles and X and gamma
areas were found which indicated a higher count rate tha
ment background, the beta reading was recorded and the insti
nen switched to the alpha mode and a reading of the alpha activi

ow Geiger-Mueller (GM) Detector, with an Eberline HP-190 probe was
tain a reading of the contaminated area at contact. This instrumen
held one meter above the floor and was used to determine g
ent background radiation levels throughout the surveyed area
ion, a Health Physics Instrument Model HPI-1010, which is a low
rating ion chamber, was used at selected locations about the p
mine background readings. This instrument was used in the integ
in order to obtain an integrated reading from several locations.

The HPI-1010 was calibrated using the gamma emissions from a Cob
) calibration source. The End Window GM detector was calibrated
gamma emissions from a Radium-226 (^{226}Ra) calibration source.
4G-3 instruments were calibrated in the alpha mode using a flat
tely thin Plutonium-239 (^{239}Pu) standard and in the beta mode
plate, infinitely thin Strontium-90-Yttrium-90 (^{90}Sr-^{90}Y) standard.
4G-3 instruments were calibrated so as to provide an apparen
etry.

It should be realized that the numerous isotopes which cou
untered will exhibit emission energies differing from that of ^{239}P
^{90}Y utilized in the calibration. When detecting known isotopes tha
and beta energies differing from that of the standards, a conv
r for the particular isotope is developed to determine the appro
.

devices, was housed in the mobile laboratory, a converted Winnebago Home.

Smear Surveys

Dry smears were taken throughout the floor pad area of Building the outside wall of the adjacent Building 331. A standard smear is pe by applying moderate pressure by the tips of the first two fingers back of the filter paper. All smears were taken with No. 1 Whatma paper, 4.25 cm in diameter. Smears of 930 cm^2 were normally taken area or object was found which had a higher than normal ins background, a smear of 100 cm^2 was taken. A smear of 100 cm^2 v taken if an area indicated excessive dirt loading. The smears were in groups of ten using a 10-Wire Flat Plate Gas Proportional D developed at ANL, utilizing an Eberline Mini Scaler Model MS-2. At l smear of each group was removed and counted in the more sensitive Measurement Corporation 2π Internal Gas Flow Proportional Counter (PC-5) using a mylar spun top. (The mylar spun top is placed over to negate the dielectric effect when counting samples on nonconductir such as paper.) This procedure was used as a more sensitive n counting a selection of the smear samples. All smears of areas or with elevated direct readings, were counted in the PC Counter. In a any smears indicating readings above the instrument background leve 10-Wire Assembly, were also counted in the PC-5 Counter. Smea

the instrumentation and smear count conversion factors used.

Table 1 includes the survey results, while the map in Figure 1A ind
location of the smears. A number, n, indicates the location c
cular smear. Figure 1B indicates the smear locations of the areas
ground; R-1 through R-4 indicate the areas with an elevated
ng.

Samples

Air samples were collected using a particulate air sampler (Pr
l) developed at ANL. (See Figure 1C for locations of air samples.
ction medium consisted of a 200 cm^2 sheet of Hollingsworth
70-0.23 mm) filter paper which collects the particulates present i
Flow rates of 15 or 40 cubic meters per hour (m^3/h) were used.
on, 5 cm in diameter, was removed from the filter media after coll
counted for both alpha and beta activity in the PC-5, utilizing a
top. The collection efficiency at these flow rates for 0.3 r
cles is approximately 99.9%. Sampling results were used to dete
n concentrations and the presence of any long-lived activity. The
le calculations are presented in Appendix 2.

Samples

Soil corings were taken at selected locations in undisturbed areas
mmediate periphery of Building 421 to determine the deposition, if a
nuclides that could have been spilled or released from the site.

corings were taken at each site to determine background levels
This was also done to identify any spurious anomalies that can
chemical (fluorometric) and gamma-ray spectral analyses were con
l soil samples.

The corings were effected using a 10.1 cm in diameter by 15.2
h right circular cylinder cutting tool, used as a golf-green hole c
core was 30 cm in length and divided into four segments. Startin
surface, three separate 5 cm segments are cut, bagged, and mark
nd C, respectively; the final segment of 15 cm was marked D. The
he segmented coring is to determine what, if any, contamination mig
occurred, to reduce the dilution of lower level soil with the upper
ents with respect to the surface deposition of the contaminants c
, and to reveal any overburden or back fill that may have occurre
ears.

Eight soil corings were effected from the grounds adjacent t
ing 421 pad area. In addition, certain of these samples were cho
be in the immediate vicinity of Building 34 and Building 41
ly, samples S-4 and S-5 were taken just south of the old Build
and sample S-7 was taken just east of the old Building 41 site.
encompassed both the 421 and 41 sites since it was located betwe
reas. Figure 1D depicts the soil sample locations.

All soil samples were processed at ANL (Figure 3) and shipped
ercial laboratory (LFE Environmental Analytical Laboratories

sample preparation consisted of weighing the samples in their c
then drying for approximately 24 hours at 80° Centigrade. All sa
then reweighed, placed into mill jars (8.7ℓ), and milled until a suf
nt of the soil sample could pass a No. 30 standard sieve. At no
the rocks and heavy material ground or pulverized since this m
l act as a diluent and, hence, lower the concentration of dep
rial. After sufficient milling, the material was sieved using a No. 3
on) standard stainless sieve. The rocks and dross vs. sieved m
segregated, bagged, and weighed separately. Soil sample weigh
n in Table 6. Aliquots of the sieved material were then loade
wtop plastic containers. The amount varied according to the ty
ysis to be performed, 100 grams for gamma spectral and radioch
rometric) analysis and 10 grams for radiochemical (fluorometic)
y effort was made throughout the sample preparation operatio
nate cross contamination. Soil samples which were suspect
aining elevated amounts of radioactivity were processed in equ
rate from the soil samples considered to contain background levels
of equipment were scrubbed and air dried prior to the introduct
next sample.

r Sample

A water sample was obtained from the storm sewer which ran alo
n side of the Building 421 concrete pad. Since it was a single
only one sample was obtained. A 118 ml sample was taken

l

his section discusses the results of the survey and the findings. G-3 instrument readings and smear results were normalized to u grations per minute per one hundred square centimeters (dis/m using the factors in Appendix 1 and are equated to natural ur ta is reported in net counts, i.e., the background count rate subtracted from the gross count rates prior to converting from minute per one hundred square centimeters (c/min-100 cm n-100 cm^2. The beta mode readings are corrected to remove any bution. The μR background readings which were taken for v s of time have been converted to μR per hour. Table 3 summariz e background reading for all modes of operation of the di ments used. The μR readings taken about the pad are preser 4 and their locations are depicted in Figure 1C.

he area accessible for survey on the floor pad was approximat ll of the outside wall area of Building 331 up to 2 meters ved.

ment Surveys

here were four areas on the concrete floor pad that indicated round readings, R-1, R-2, R-3 and R-4. The locations of these nown in Figure 1B. The beta-gamma readings at these four lo 8.4×10^2 dis/min-100 cm^2, 2.2×10^5 dis/min-100 cm^2, 2.2

s R-1, R-2 and R-3 were 100 cm^2 or less. Spot R-4 was found
surface of the concrete and was approximately 5 000 cm^2.

The highest End Window reading was indicated at Spot R-2. Th
ow reading was 0.09 mR/h with the instrument in contact with the
of the other three spots indicated an elevated direct reading wi
Window Detector.

Eight background measurements using a Micro R meter were taken
ling pad. These μR readings ranged from 4.9 μR/h to 11.5 μR/h
e of μR background readings in an uncontaminated area is 7-12
of the μR readings taken on the concrete pad were found to be
e.

A sample of spot R-2 was extracted and submitted for gamma s
ysis. Figure 2 shows the gamma spectrum that was observed usi
channel Analyzer. Results of this analysis indicate the contaminant
ral uranium; therefore, the PAC-4G-3 instrument readings are equa
ral uranium.

No elevated readings were found on the outside wall of Buildin

r Surveys

Smears were randomly taken on the Building 421 floor pad and
ding 331 wall which is next to the Building 421 floor pad. Smear
taken on the four spots of contamination found on the floor pa
rable contamination was found.

vn in Appendix 2, the Radon-222 Working Level (WL) concentrations
rmined at these locations. The results were 0.00013 WL, 0.00011 WL
009 WL, respectively.

According to the Surgeon General's Guidelines found in 10 CFR
centrations of radon daughters below 0.03 WL do not require reme
on in structures other than private dwellings or schools. (A copy of
geon General's Guidelines is found in Appendix 6.)

Samples

Results submitted by LFE Environmental Analysis Laboratories, as li
Table 8, are reported in picocuries per gram (pCi/g) for the Germa
hium) [Ge(Li)] spectral analysis and in micrograms per gram (µg/g)
uranium fluorometric analysis. The latter concentrations were converte
/g by means of the example calculation shown in Appendix 4.

The soil sample data along with background soil sample data is prese
Table 7. The background soil samples indicate natural ura
centrations ranging from 0.9 to 4.8 pCi/g with one exception. Th
2B which was 12.2 pCi/g. Since samples SM-1 and SM-2 were take
e proximity, it is expected that their results should be similar. The
/g sample may be a result of soil fertilization. Since elev
centrations of uranium are present where phosphate-containing fertil
used, any fertilizing of the soil can result in an increased ura
centration. Results of soil samples taken at the Watertown Arsenal
hin the range of 0.9 to 4.8 pCi/g of uranium.

The water sample obtained in the storm sewer was counted c
hannel Analyzer. No radioactivity above background was detec
ample.

mination Guidelines

Both the draft ANSI Standard N13.12 for the "Control of Radi
ce Contamination on Materials, Equipment, and Facilities to Be Re
Uncontrolled Use" and the NRC Guideline for "Decontaminat
ies and Equipment Prior to Release for Unrestricted Use or Term
censes for By-Product, Source, or Special Nuclear Material",
ered as guidelines (see Appendix 5).

Since natural uranium was identified, the acceptable s
mination levels for natural uranium will be used. The NRC Guidel
al uranium is as follows: the average is 5 000 dis/min-100 cm^2
um is 15 000 dis/min-100 cm^2 α, and the removable is 1 000 dis/n
. The measurements for the average may not be averaged ove
one square meter and the maximum level applies to an area of nc
00 cm^2. Also, the average and maximum radiation levels associate
ce contamination resulting from beta-gamma emitters should not
rad/h at 1 cm and 1.0 mrad/h at 1 cm, respectively, measured t
ore than 7 mg/cm^2 of total absorber.

The ANSI Standard N13.12 is more limiting than the NRC Gui
l uranium. The allowable natural uranium activity is 5 000 dis/n

Standard is more restrictive in that its limits include both alp activity and the NRC Guide includes only alpha activity. In t contamination found at Watertown Arsenal, beta-gamma activity is no alpha activity was detectable. It is important to note that a dirt on the concrete pad could prevent the detection of alpha p this occurred, an area of contamination would meet the NRC Gu would exceed the ANSI Standard levels.

The areas of fixed contamination which were found to be the 5 000 dis/min-100 cm^2 total for natural uranium as given Standard are depicted in Figure 1B and are as follows:

Location	Counting Results
R-2	2.2×10^5 dis/min-100 cm^2
R-3	2.2×10^5 dis/min-100 cm^2
R-4	8.5×10^4 dis/min-100 cm^2.

In an effort to evaluate the radiological health hazard associated w
ur contaminated spots on the pad at the Watertown Arsenal, a credib
pothetical situation will be determined. One such situation which
se, would involve the disturbance of contaminated concrete. A pn
khammering of the contaminated spot could result in a radioactive a
is would appear to be a satisfactory form to consider for purp
sessing a potential radiological hazard.

Even though the contamination found at R-4 is not the highest p
ea, this spot will be used to assess the radiological hazard since it c
the greatest level of total activity. The level of activity found at R
5 x 10^4 dis/mln-100 cm^2 equated to natural uranium[1] (dis/min(
^{2}).

When the sample from R-2 was taken by scraping the concrete w
atula, the level of activity was decreased by approximately one h
uld appear that most of the activity at R-2 is confined to the top 0.
e concrete. But since the contamination at R-4 is not found in cr
e cement, it will be assumed that this level of 8.5 x 10^4 dis/min-100
nstant through a depth of 10 cm and that this level of 8.5 x 10^4 d
0 cm^2 is present in every 0.6 cm depth. This assumption will resu
nservative estimate of the internal exposure hazard.

cm^2 and the the depth of the jackhammering would be 10 cm, the tot
(A) involved would be as follows:

$$A = \frac{8.5 \times 10^4 \text{ dis/min}_{(nu)} - 100 \text{ cm}^2}{0.6 \text{ cm}} \cdot 10 \text{ cm} \cdot 5\,000 \text{ cm}^2$$

$$= 7.1 \times 10^7 \text{ dis/min}_{(nu)}.$$

This is also equal to

$$A = 7.1 \times 10^7 \text{ dis/min}_{(nu)} \cdot \frac{1 \text{ } \mu\text{Ci}_{(nu)}}{2.22 \times 10^6 \text{ dis/min}_{(nu)}}$$

$$= 3.2 \times 10^1 \text{ } \mu\text{Ci}_{(nu)}.$$

Assuming the depth of the concrete cut from the jackhammer
cm, the volume of concrete displaced (B) would be as follows:

$$B = 10 \text{ cm} \cdot 5\,000 \text{ cm}^2 = 5 \times 10^4 \text{ cm}^3.$$

The activity per unit volume of concrete (C) would be as follows:

$$C = \frac{3.2 \times 10^1 \text{ } \mu\text{Ci}_{(nu)}}{5 \times 10^4 \text{ cm}^3} = \frac{6.4 \times 10^{-4} \text{ } \mu\text{Ci}_{(nu)}}{\text{cm}^3}.$$

Since jackhammering results mainly in large pieces of concrete ra
small particles, the assumption will be made that

tivity per gram of total concrete suspended in the air (D) would

$$\frac{.4 \times 10^{-4}\ \mu Ci_{(nu)}}{cm^3} \cdot \frac{cm^3}{3g} = \frac{2.1 \times 10^{-4}\ \mu Ci_{(nu)}}{g}.$$

ne can assume that the concrete is dry and that a maximum
would be created from the jackhammer disturbance.
his maximum dust burden would, however, most probably be no gr
ne Threshold Limit Value (TLV) for Nuisance Particulates. The T
m^3 of air or 1.5×10^{-2} g/m^3(3).
an aerosol was generated which contained this TLV, the concentr
radionuclide (E) in the air would be:

$$\frac{2.1 \times 10^{-4}\ \mu Ci_{(nu)}}{g} \cdot \frac{1.5 \times 10^{-2}\ g}{m^3} = 3.2 \times 10^{-6}\ \mu Ci_{(nu)}$$

2×10^{-12} $\mu Ci_{(nu)}/cm^3$.

should be realized that only a limited number of people cou
involved in such a postulated environment for any length of time
n, the level of concrete dust described herein would probab

In the preceding situation we have generated an aerosol 1.6

Since the jackhammering of the small area would not ta
the particles would soon fall out of suspension, the aerosol c
to last only 10 minutes. A person involved in this operatio
of time would inhale the following level of activity (G):

$$G = \frac{1.2\ m^3\ of\ air}{60\ min} \cdot 10\ min \cdot \frac{3.2 \times 10^{-6}\ \mu Ci_{(nu)}}{m^3} = 6.4 \times 1$$

The fraction reaching the organ of reference, which ir
kidneys, would be 0.028[6]. Therefore, the total reaching
would be:

$$H = 6.4 \times 10^{-7}\ \mu Ci_{(nu)} \cdot 0.028 = 1.8 \times 10^{-8}\ \mu Ci_{(nu)}.$$

The maximum permissible burden of uranium for the kidi
body, [q(k)], is $5 \times 10^{-3}\ \mu Ci_{(nu)}$[7]. Comparing the t
kidneys to the maximum permissible kidney burden the follo
obtained:

$$I = \frac{1.8 \times 10^{-8}\ \mu Ci_{(nu)}}{} = 3.6 \times 10^{-6}.$$

us, the person would receive 3.6 x 10 of a kidney burden

ration.

Even though these calculations are based on reasonable hypo

ues, it must be realized that the actual activity could be greater

culated value. Simultaneous use of the jackhammer at the oth

taminated areas would not significantly increase the hazard.

Only the GM End Window reading taken in contact with the

s found to be greater than the instrument background. The readin

ot was 0.09 mR/h. None of the GM End Window readings taken

m the contaminated spots were distinguishable from the normal in

ckground range of 0.03 to 0.05 mR/h. Therefore, no external h

visioned.

from ^{235}U. This equals 4.5×10^{12} dis/min per Curie of natural uran
A standard Curie is 2.22×10^{12} dis/min.

Density of Elements and Common Material, as given in the Radiolog
Health Handbook, January, 1970.

The Threshold Limit Value is 15 mg/m^3 for Nuisance Particulates f
the Occupational Safety and Health Standards subpart Z - Toxic
Hazardous Substances, May 28, 1975.

The Maximum Permissible Concentration values are given in "Standa
for Protection Against Radiation," Code of Federal Regulations, Ti
10, Part 20, Appendix B (April 30, 1975) (10 CFR 20), for an ins
uble radionuclide in air in an uncontrolled area.

Specifications for Standard Man as given in the Radiological Health Han
book, January, 1970.

Report of Committee II of Permissible Dose from Internal Radiation (1959
International Committee on Radiological Protection (ICRP).

This is the maximum permissible kidney burden for ^{238}U as found in th
eport of Committee II of Permissible Dose from Internal Radiation (1959
ternational Committee on Radiological Protection (ICRP).

A comprehensive radiological survey was completed at the Watertown, Watertown, Massachusetts. This site was used as and office areas for the preparation and processing of uranium.

Direct instrument survey of the pad of Building 421 a exterior wall of Building 331 which is adjacent to the pad, indic areas of contamination on the Building 421 pad. These four s R-1, R-2, R-3 and R-4 on the maps, consist of the following tamination: 8.4 x 10^2 dis/min-100 cm^2 beta-gamma, 2.2 x 10^5 di beta-gamma, 2.2 x 10^5 dis/min-100 cm^2 beta-gamma and 8.5 x 1 cm^2 beta-gamma. No alpha contamination was detected. Ga analysis of a chip of contaminated concrete from spot R-2 indi contaminant is natural uranium. Three of the spots, R-2, exceed the allowable limits for natural uranium as found in the A No. N13.12 "Control of Radioactive Surface Contamination Equipment, and Facilities to Be Released for Uncontrolled Use these four areas indicate that the contamination is fixed and n None of the four areas of contamination were found to be larg cm^2.

The highest End Window reading of 0.09 mR/h was indi R-2. None of the other three spots indicated an elevated direc the End Window Detector.

Integrated background measurements using the HPI 1010 seven location on the pad. These readings ranged from 4.9

reater than the normal background.

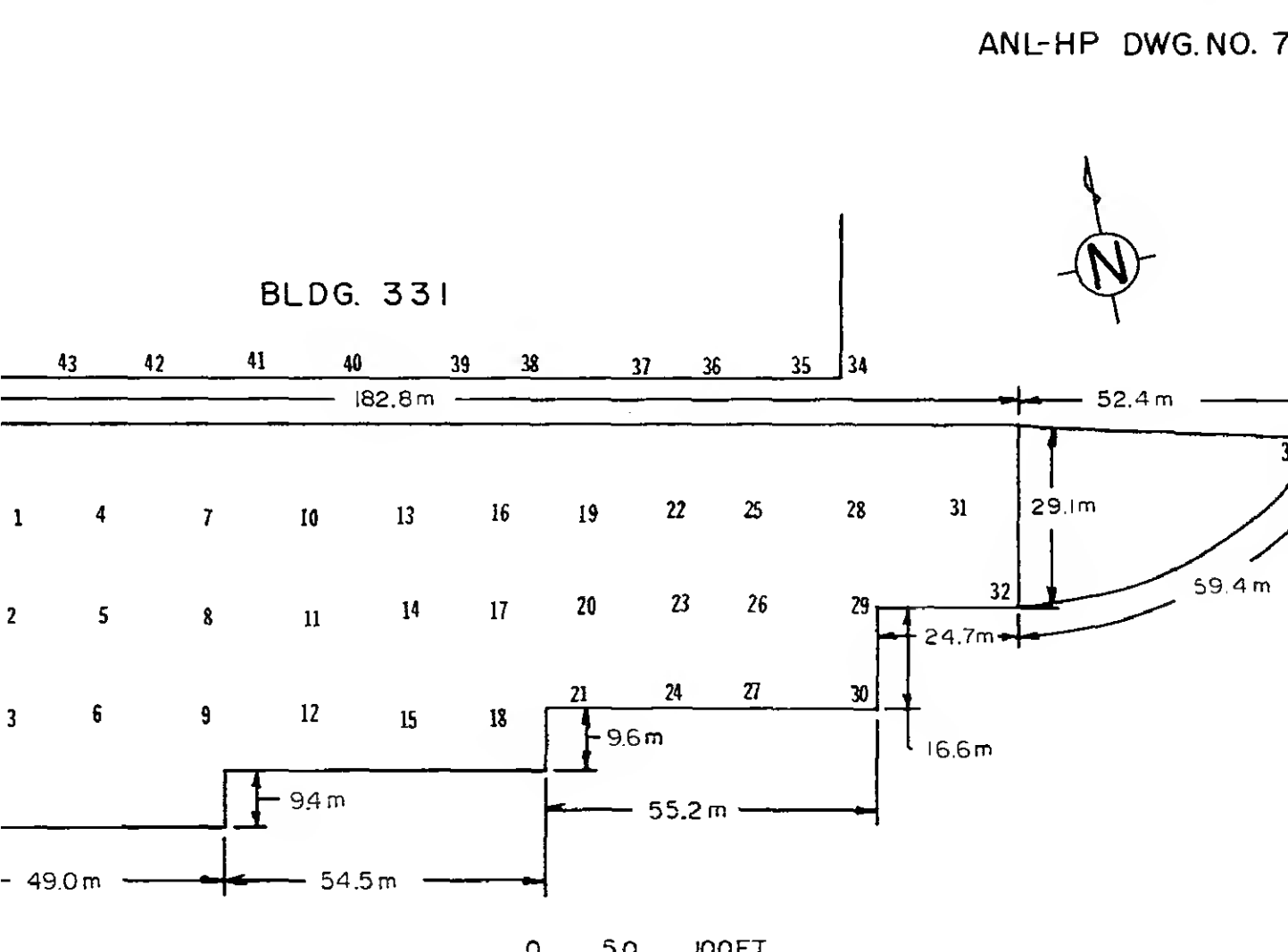
The concentrations of radon daughters were determined at three loca
n the Building 421 pad. These were 0.00013 WL, 0.00011 WL and 0.
L. According to the Surgeon General's Guidelines found in 10 CFR
oncentrations of radon daughters below 0.03 WL do not require ren
ction in structures other than private dwellings and schools.

Eight soil samples were taken at locations about the site. To c
ackground soil sample data, samples were collected in areas which app
be undisturbed since the MED/AEC era. An elevated level of uranium
oted in one background soil sample. This elevated uranium level is pro
result of the addition of phosphate fertilizer to the soil. Disregarding
mple, the background soil samples ranged from 0.9 to 4.8 pCi/g of na
ranium.

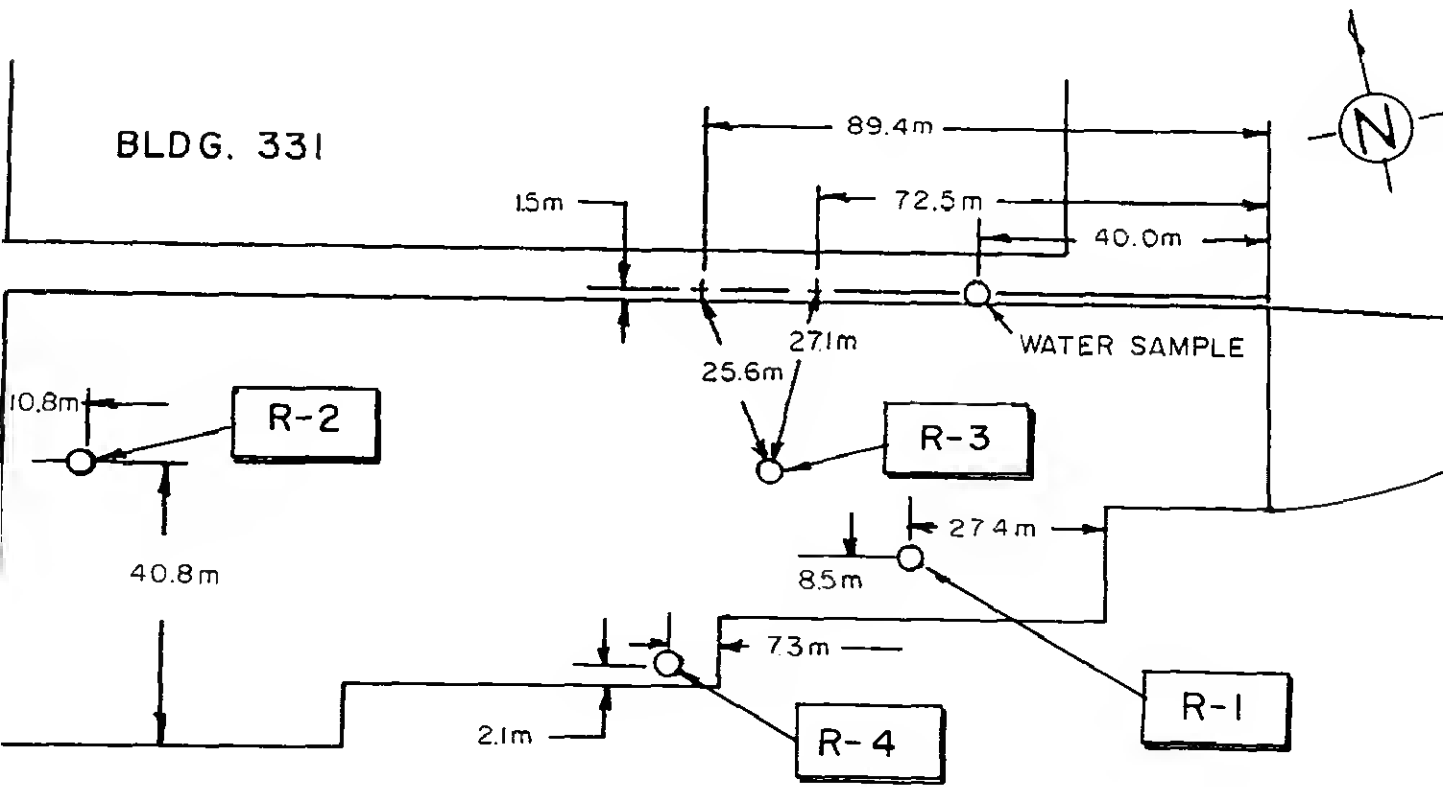
The levels of uranium found in the soil samples taken about the
nged from 0.8 to 4.1 pCi/g. Results of the soil samples indicate
evated levels above the natural background levels in the soil.

One water sample was obtained from the storm sewer line on the
de of the Building 421 pad. A gamma spectral analysis indicate
dioactivity in the sample. It is therefore felt that no contaminati
resent in this sewer.

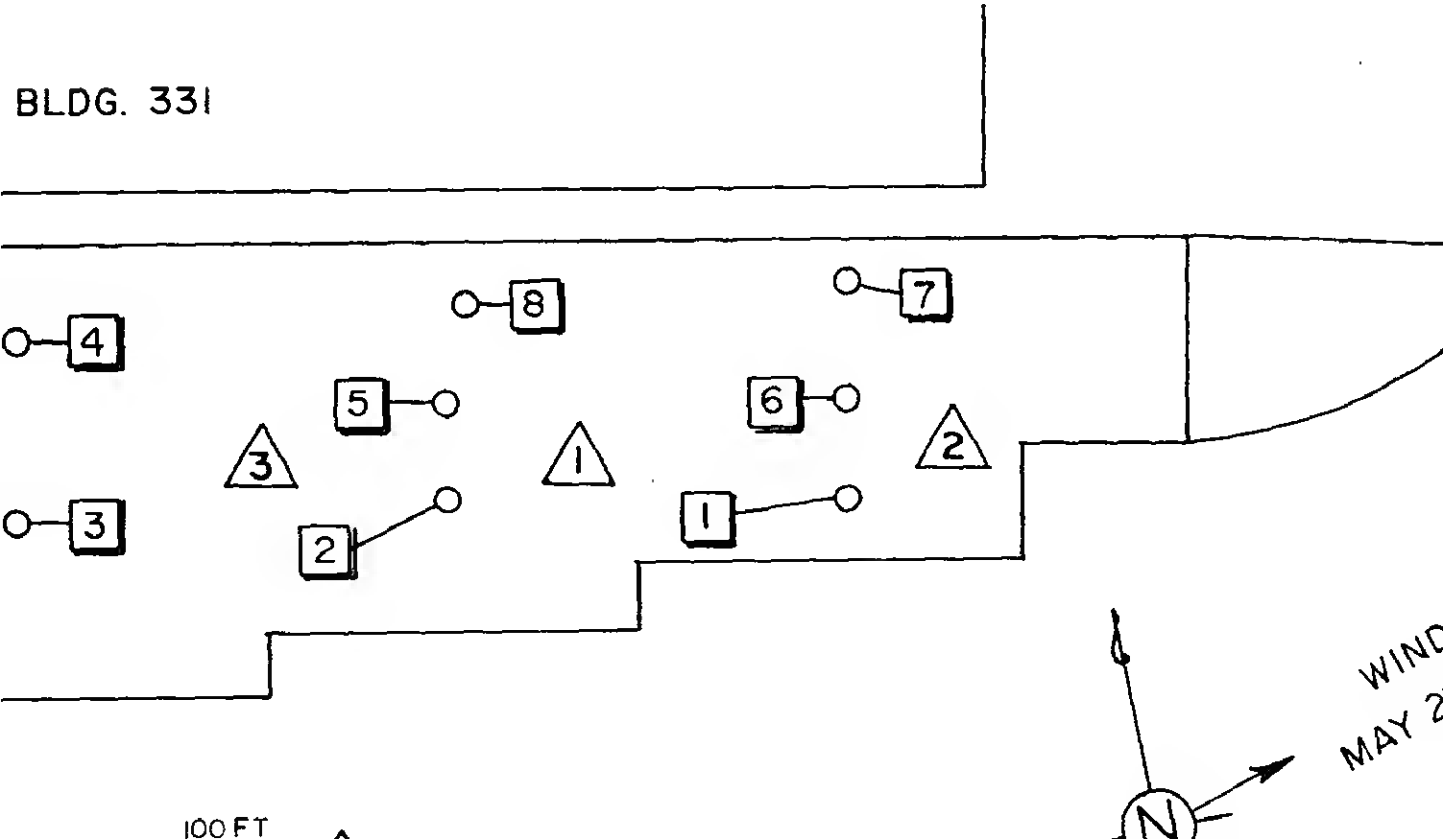
ANL-HP DWG. NO. 7

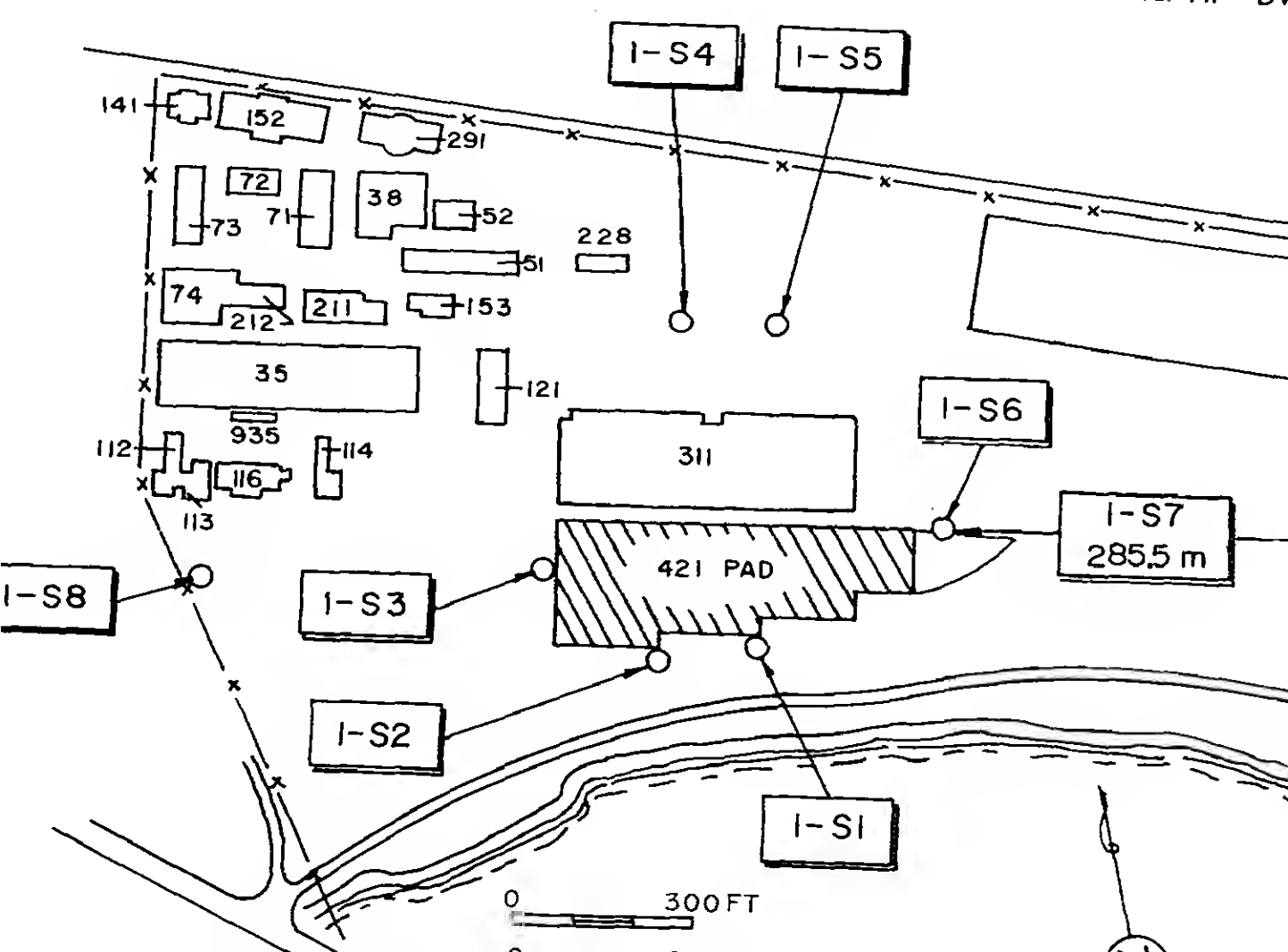


ANL-HP DW


BLDG. 331
89.4m
72.5m
40.0m
1.5m
27.1m
25.6m
WATER SAMPLE
10.8m
R-2
R-3
40.8m
27.4m
8.5m
7.3m
R-1
2.1m
R-4
N

ANL-HP DWG. NO.

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112
114
116
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I-S1
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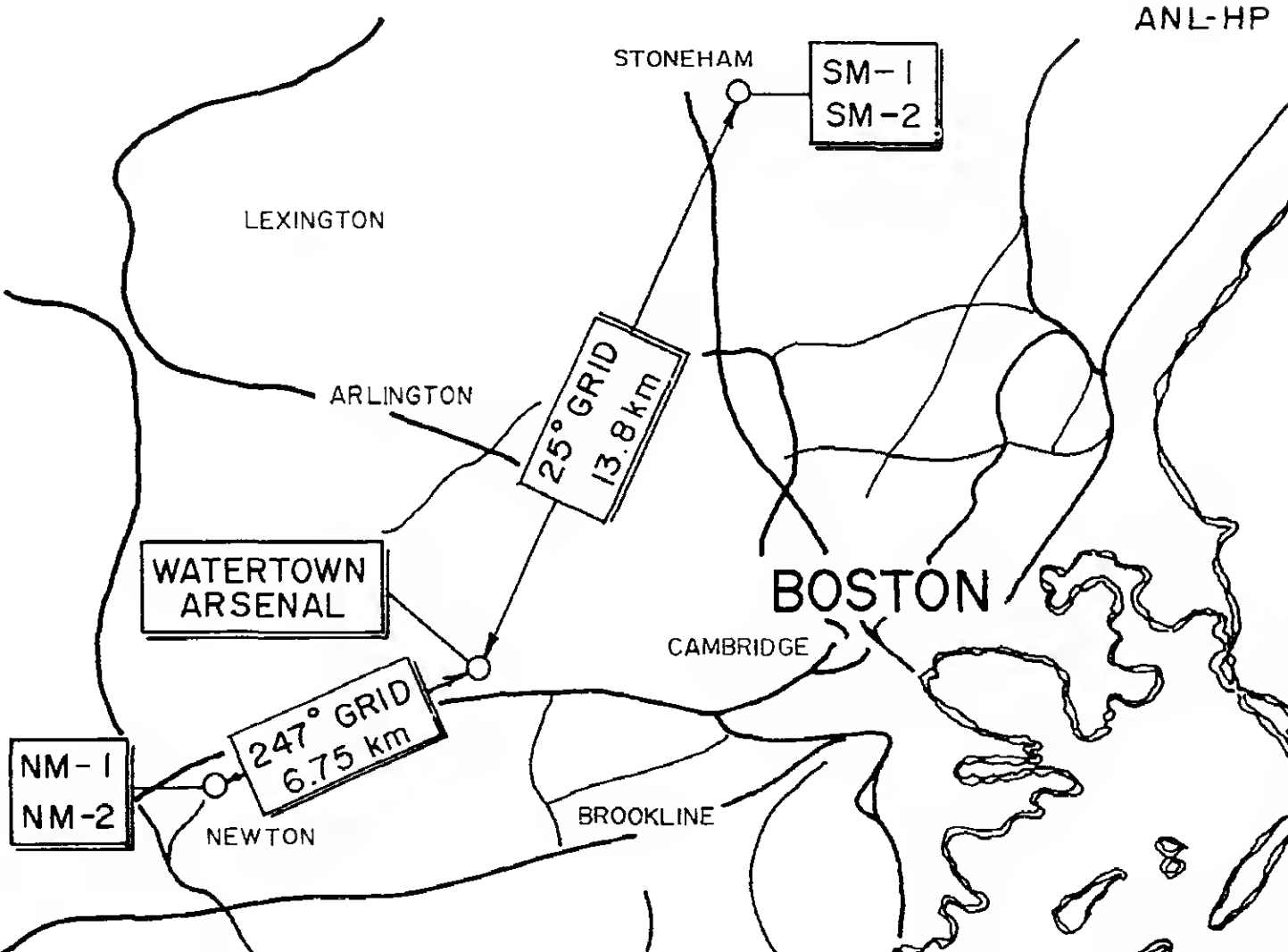
ANL-HP
STONEHAM
SM-1
SM-2
LEXINGTON
ARLINGTON
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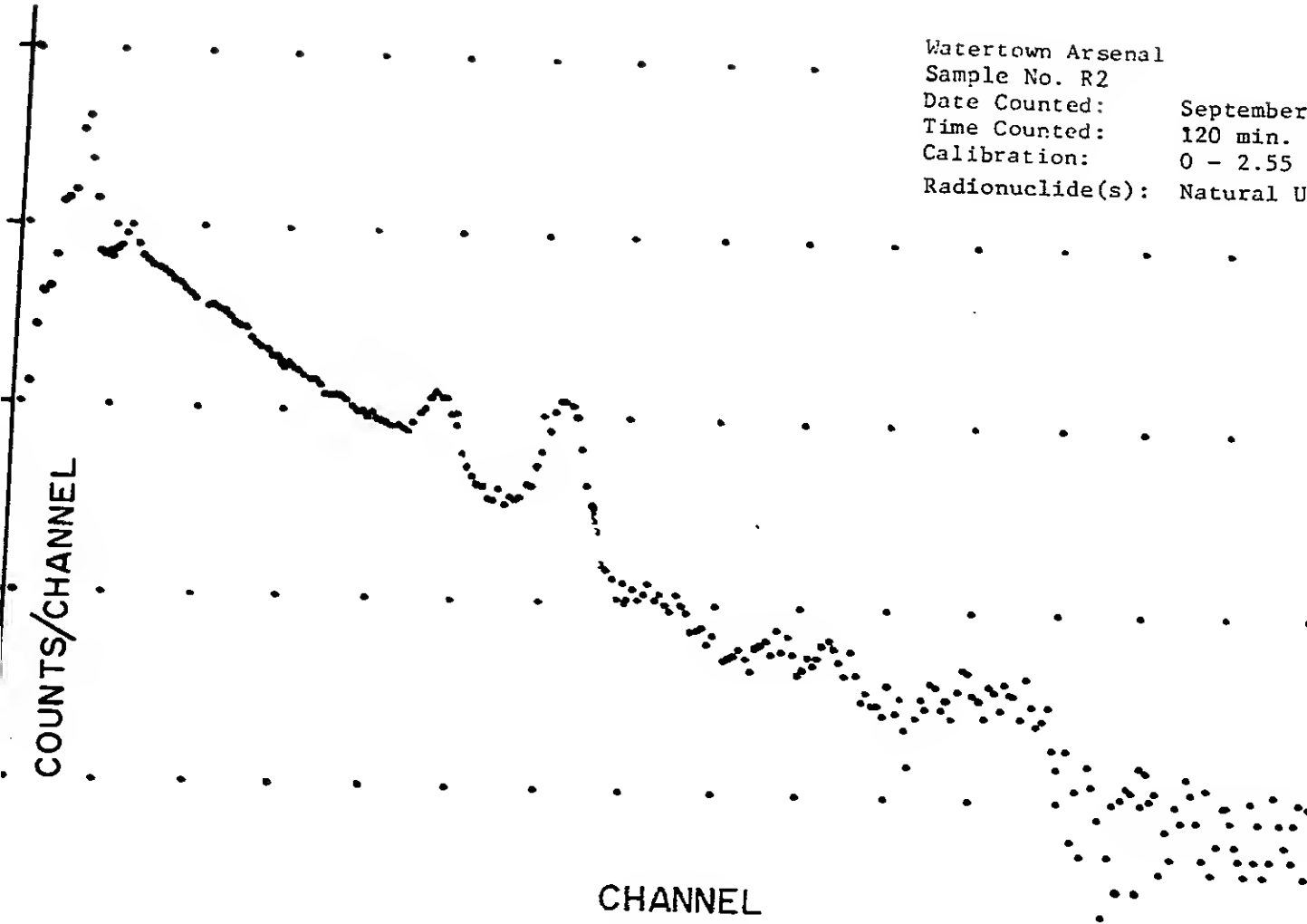
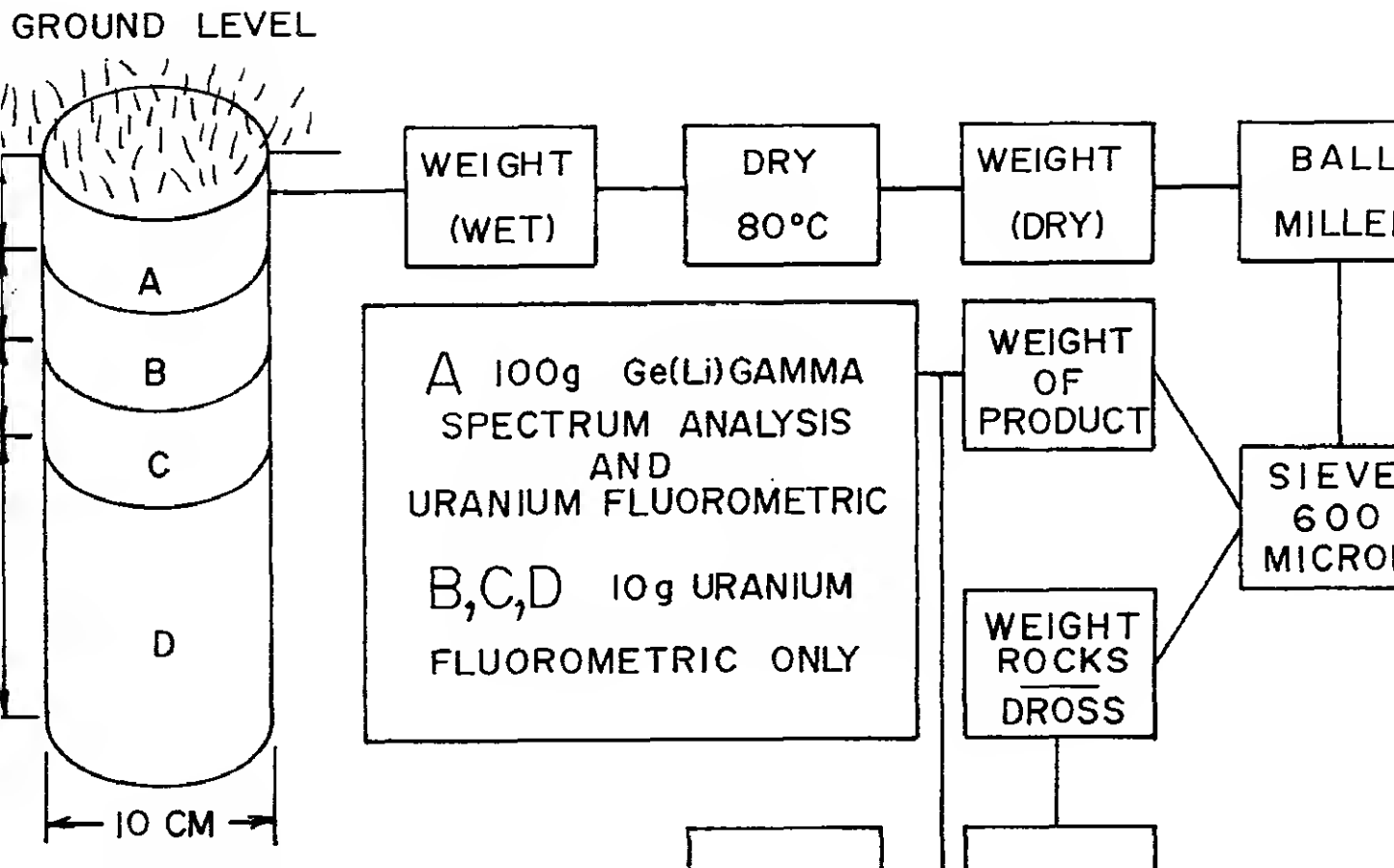
13.8 km
WATERTOWN
ARSENAL
BOSTON
CAMBRIDGE
247° GRID
6.75 km
NM-1
NM-2
NEWTON
BROOKLINE


Watertown Arsenal
Sample No. R2
Date Counted: September
Time Counted: 120 min.
Calibration: 0 - 2.55
Radionuclide(s): Natural U
COUNTS/CHANNEL
CHANNEL

SOIL SAMPLING PROCEDURE AND PROCESSING DIAGRAM

ANL-HP-DWG



a beta mode reading was obtained. The instrument was then swi ed to the alpha mode and a reading of the alpha contamination obtained. In the alpha mode the instrument only responds to pa cles with high specific ionization such as alpha particles.

The beta mode readings are compensated for any alpha con bution.

(b) BKGD (Background) The following are the instrument backgro readings:

	Beta Mode	Alpha Mode
Floor Monitor	1500-2000 c/min-325 cm^2	0-50 c/min-325 cm^2
PAC-4G-3	150- 200 c/min-51 cm^2	0-50 c/min-51 cm^2
PC Counter	50 c/min	1.0 c/min
10 Wire	500 c/min	10 c/min

GM End Window Detector read 0.03 to 0.05 mR/h at 1 meter above floor.

(c) NA (Non-applicable) No contamination was detected above ba ground in the beta mode; therefore, no alpha mode or contact End Window Survey was necessary.

Percent of Area Accessible for Survey		Air Sample (WL)	Direct Readings[a] (dis/min-100 cm^2)		End Window (mR/h)		Smear Results (dis/min-100 cm^2)	Comme
Floors	Walls		Beta	Alpha	Contact	1 Meter		
95	No Walls	0.00013 0.00011 0.00009						Air Sam Air Sam Air Sam
			$8.4x10^2$	BKGD[b]	BKGD	BKGD	BKGD	Spot of R-1 equ uranium
			$2.2x10^5$	BKGD	0.09	BKGD	BKGD	Spot of R-2 equ uranium
			$2.2x10^5$	BKGD	BKGD	BKGD	BKGD	Spot of R-3 equ uranium
			$8.5x10^4$	BKGD	BKGD	BKGD	BKGD	Spot of R-4 equ uranium
			BKGD	NA[c]	NA	BKGD	BKGD	Rest of

	Inventory Number	Probe Area	Wir Thi
erline Floor Monitor -4G utilizing a PAC-4G-3	181501	325 cm^2	0.85
erline Floor Monitor -4G utilizing a PAC-4G-3	183413	325 cm^2	0.85
erline Floor Monitor -4G utilizing a PAC-4G-3	184340	325 cm^2	0.85
C-4G-3	183412	51 cm^2	0.85
C-4G-3	183414	51 cm^2	0.85
C-4G-3	183415	51 cm^2	0.85
C-4G-3	184339	51 cm^2	0.85
C-4G-3	184341	51 cm^2	0.85
rline HP-90 a-Gamma End Window	159006	-	4.1 - 4.
lear Measurement Corp. 5 2π Internal Gas Flow nter	184065	-	0.85
onne National Laboratory Wire Flat Plate Gas portional Detector with rline Mini Scaler MS-2	184342 184343	400 cm^2	0.85
onne National Laboratory r Queen Air Sampler using 70 filter media	-	-	
th Physics Instrument el HPI-1010	184444	-	
ear Data Multichannel yzer Model ND-100	184764	-	

INSTRUMENT BACKGROUND READINGS

ent	Readings* Alpha Mode (c/min)	Beta Mode (c/min)	l meter fl
: Floor FM-4G AC-4G-3			
	0 - 50	1 500 - 2 000	
	0 - 50	1 500 - 2 000	
	0 - 50	1 500 - 2 000	
: PAC-4G-3			
	0 - 50	150 - 200	
	0 - 50	150 - 200	
	0 - 50	150 - 200	
	0 - 50	150 - 200	
	0 - 50	150 - 200	
: 530 with Beta-Gamma dow	-	-	0.0
Measurement C-5 2π Gas unter	0.3	40	
e National ory 10-Wire Flat as Proportional r with Eberline aler MS-2	10	500	
Physics Instrument PI-1010			7-12

kground readings were initially taken in the mobile laboratory and hecked throughout the various areas while surveying.

Number	Date	Reading* μR/h
1	5-23-77	11.5
2	5-23-77	10.0
3	5-23-77	8.2
4	5-24-77	5.3
5	5-24-77	10.9
6	5-24-77	9.7
7	5-25-77	9.4
8	5-25-77	4.9

rmal background readings range from 7 - 12 μR/h.

cation	Date	dis/min-m³	pCi/ℓ	WL*
	5-25-78	29	0.013	0.00013
	5-25-78	25	0.011	0.00011
	5-25-78	20	0.009	0.00009

ample Calculation #1

$$0.013 \text{ pCi}/\ell \cdot \frac{\text{WL}}{100 \text{ pCi}/\ell} = 0.00013 \text{ WL}$$

Working Level (WL) is defined in 10 CFR 712 as any combin
ort-lived radon daughter products in 1 liter of air that will resul
imate emission of 1.3×10^5 MeV of potential alpha energy. The n
ue of the WL is derived from the alpha energy released by the tot
rough RaC' of the short-lived radon daughter products, RaA, RaB,
lioactive equilibrium with 100 pCi of ^{222}Rn per liter of air.

Sample No.	Weight (grams)	Weight (grams)	Weight (grams)	Dr (gra
		SOIL SAMPLES		
1-S1-A	466.1	451.4	405.1	39
1-S1-B	998.2	970.0	921.2	43
1-S1-C	823.6	791.2	754.1	34
1-S1-D	2219.0	2047.4	1910.6	128
1-S2-A	842.5	819.2	757.4	58
1-S2-B	685.5	650.8	604.4	45
1-S2-C	993.7	937.2	861.3	74
1-S2-D	2175.6	2032.4	1586.6	431
1-S3-A	906.0	887.9	840.0	33
1-S3-B	848.6	838.1	822.8	10
1-S3-C	1045.5	1022.9	942.4	75
1-S3-D	2749.0	2676.2	1875.5	785
1-S4-A	1051.9	1040.3	536.8	499
1-S4-B	1111.0	1093.1	418.9	666
1-S4-C	2326.7	2284.3	752.3	1526
1-S4-D	5208.6	5095.2	1416.4	3557
1-S5-A	781.9	777.8	569.8	201
1-S5-B	1192.2	1175.6	451.5	720
1-S5-C	1521.8	1494.2	701.2	781
1-S5-D	3058.8	2936.9	943.3	1961
1-S6-A	637.4	626.9	395.5	220
1-S6-B	851.0	826.6	481.1	337
1-S6-C	1048.3	1007.4	537.8	463
1-S6-D	2692.6	2553.8	926.3	1619
1-S7-A	241.1	234.1	197.4	26
1-S7-B	531.8	522.6	304.8	210
1-S7-C	1653.8	1631.0	551.4	1075
1-S7-D	5387.0	5347.2	1385.4	3915
1-S8-A	352.5	289.1	262.5	23
1-S8-B	368.4	308.4	299.3	3
1-S8-C	727.1	622.0	574.7	40
1-S8-D	1529.9	1522.8	942.6	350

(cont'd)

o.	Net Weight (grams)	Dry Weight (grams)	Sieved Weight (grams)	Rocks and Dross (grams)
		BACKGROUND SOIL SAMPLES		
	519.1	416.5	356.7	53.5
	668.4	588.8	334.0	247.5
	777.0	668.9	534.0	111.3
	1887.5	1622.9	1182.8	434.4
	752.5	613.9	471.7	131.7
	342.0	272.5	236.2	30.7
	983.0	814.3	699.1	108.3
	1779.4	1496.4	1271.3	211.4
	466.8	387.6	358.6	11.9
	789.9	705.4	425.4	275.0
	724.7	627.9	439.1	186.3
	1353.0	987.8	772.2	196.5
	811.1	666.6	612.2	49.5
	568.1	366.4	360.1	2.7
	487.8	331.7	324.0	3.5
	1214.4	849.6	835.0	10.6

ple	Ge(Li) Spectra pCi/g received wt ± σ[1]			
	^{137}Cs	^{232}Th Decay Chain	^{226}Ra Decay Chain	U μg/g ± σ[2]
-A	0.09 ± 0.04	0.7 ± 0.1	0.61 ± 0.06	2.1 ± 0.4
-B				1.5 ± 0.4
-C				2.4 ± 0.9
-D				1.8 ± 0.4
-A	0.09 ± 0.04	0.6 ± 0.1	0.49 ± 0.06	1.9 ± 0.4
-B				1.5 ± 0.4
-C				1.5 ± 0.5
-D				1.3 ± 0.3
-A	0 ± 0.04	0.7 ± 0.1	0.51 ± 0.06	1.5 ± 0.4
-B				1.5 ± 0.4
-C				1.2 ± 0.3
-D				1.2 ± 0.4
-A	0.74 ± 0.04	0.8 ± 0.1	0.86 ± 0.06	2.2 ± 0.4
B				3.1 ± 0.6
C				3.1 ± 0.8
D				2.1 ± 0.6
A	2.6 ± 0.1	0.8 ± 0.1	0.86 ± 0.06	5.9 ± 0.7
B				2.5 ± 0.3
C				5.6 ± 0.7
D				5.0 ± 0.9
A	1.40 ± 0.07	0.9 ± 0.1	0.62 ± 0.06	3.1 ± 0.7
B				2.9 ± 1.4
C				2.5 ± 0.8
D				3.2 ± 0.8
A	2.7 ± 0.1	0.6 ± 0.1	0.62 ± 0.06	1.9 ± 0.7
B				2.2 ± 0.4
C				1.6 ± 0.4
D				2.5 ± 0.4

Ge (Li) Spectra pCi/g received wt ± $\sigma^{(1)}$				
^{137}Cs	^{232}Th Decay Chain	^{226}Ra Decay Chain	Uraniu µg/g ± $\sigma^{(2)}$	pC
3.3 ± 0.2	1.2 ± 0.2	1.58 ± 0.09	4.6 ± 0.5	3.
			2.8 ± 0.4	2.
			3.7 ± 0.5	2.
			3.8 ± 0.4	2.
	BACKGROUND SOIL SAMPLES			
1.25 ± 0.06	1.2 ± 0.1	0.96 ± 0.06	3.4 ± 0.5	2.
			4.3 ± 0.6	3.
			4.1 ± 0.6	2.
			3.1 ± 0.4	2
0.91 ± 0.05	1.5 ± 0.1	1.00 ± 0.07	2.5 ± 0.5	1
			6.8 ± 0.6	4
			3.5 ± 0.5	2
			3.2 ± 0.4	2
2.2 ± 0.1	0.9 ± 0.1	0.68 ± 0.06	2.5 ± 0.4	1
			2.2 ± 0.4	1
			1.3 ± 0.4	0
			2.4 ± 0.4	1
0 ± 0.05	0.9 ± 0.1	0.72 ± 0.06	4.0 ± 0.4	2
			17.4 ± 0.8	12
			5.0 ± 0.4	3
			3.2 ± 0.4	2
ık 0 ± 0.4	0 ± 0.1	0 ± 0.06	0 ± 0.2	

e standard deviation due to counting statistics.
a results from LFE.
L conversion from Appendix 4.

Below are the conversion factors used to obtain the reac
disintegrations per minute per 100 cm^2 (dis/min-100 cm^2).

I Conversion Factors

	PAC-4G-3	Floor Monitor (F
To 100 cm^2	1.96	0.31
c/min to dis/min (alpha)	2	2
c/min to dis/min (beta)	2	2
c/min to dis/min (alpha from natural uranium)	3.7	3.7
c/min to dis/min (beta-gamma from natural uranium)	4.3	3.6

II Deriviation of Conversion Factors

Floor Monitor (FM-4G)

Window Area: ~325 cm^2
Conversion to 100 cm^2 = 0.31 times Floor Monitor reading.

PAC-4G-3

Window Area: ~51 cm^2
Conversion to 100 cm^2 = 1.96 times PAC reading.

2π Internal Gas Flow Counter, PC-5

Geometry: Solid Stainless Steel Spun Top - 0.50
Geometry: Mylar Spun Top - 0.43
Mylar Spun Top Counting (double aluminized mylar window ~0.85 mg/cm^2) utilizes the well of the PC-5 and is a method developed and used by the Argonne National Laboratory Health Physics Section for negating the dielectric effect in counting samples on

ing a 3.2 cm x 3.2 cm x 0.3 cm natural uranium plate as a sou
ium alpha emissions, the plate was counted in the well of a 2π i
flow counter, PC-5, with the source leveled to an apparent 2π geo

alpha c/min was found to be 27 596 c/min or 27 596/0.50 = 5.519
in.

the floor monitor (FM-4G) and the uranium source to convert
minute (c/min) to disintegrations per minute (dis/min), the cou
d to be 15 000 c/min at contact; therefore, $5.519 \times 10^4/15\ 000$
in to c/min.

milar reading was indicated on the PAC-4G-3, thus indicating th
r for converting natural uranium c/min to dis/min from eith
4G-3 or the floor monitor in the alpha mode.

same natural uranium source, covered with 2 layers of noncond
r, each 6.65 mg/cm² to negate the alpha emissions, was count
osite beta and gamma emissions in the PC-5. The source was lev
pparent 50% geometry; however, no provision was made for backs

composite beta-gamma count was found to be 538 066 c/min or 538 0
76×10^6 dis/min.

the FM-4G floor monitor in the beta mode and in contact wi
ed natural uranium source and centered on the probe, the cou
l to be 300 000 c/min; this indicates a conversion factor of 1 07
00 = 3.6 dis/min to c/min.

the same covered source for the PAC-4G-3 beta mode conversi
ct and centered on the probe, the count was found to be 250 000
conversion factor of 1 076 000/250 000 = 4.3 dis/min to c/min.

SMEAR COUNT

The conversion factors for c/min-100 cm² to dis/min-100 cm² are
.

I Conversion Equation (Alpha)

$$\frac{n - (Bkgd)}{bf \cdot sa \cdot waf} = \text{dis/min Alpha}$$

ometry (g) of 0.43 is standard for all flat plate counting.

ne self-absorption (sa) was assumed to be 1 unless otherwise dete

the energies of the isotope were known, the appropriate window ai
vaf) was used; if the energies of the isotopes were unknown, the
^{239}Pu, which is 0.713, was used.

ne waf for natural uranium alphas is 0.54.

II Conversion Equation (Beta)

$$\frac{\text{/min} - [\text{Beta Bkgd (c/min)} + \text{Alpha c/min}]}{g \cdot bf \cdot sa \cdot waf} = \text{dis/min Beta}$$

geometry (g) of 0.43 is standard for all flat plate counting using th
oun top.

backscattter factor (bf) of 1.1 is used when determining beta activi
ter media.

ne self-absorption (sa) was assumed to be 1 unless otherwise dete

the energies of the isotopes were known, the appropriate window ai
vaf) was used; if the energies of the isotopes were unknown, the
Sr-^{90}Y, which is 0.85 was used.

ne waf for natural uranium betas is 0.85.

This appendix summarizes the air sampling calculations f
ollected using an Argonne National Laboratory designed air sa
V-70 filter media. The attachment includes the basic assum
alculations used to derive the air concentrations.

. Radon Concentrations Based on RaC' Results

The following postulates are assumed in deriving the Radon-2
concentrations as based on the RaC' alpha count results.

1. RaA, RaB, RaC, RaC', are in equilibrium.

2. RaA is present only in the first count and not the 100 m
count.

3. One half of the radon progeny is not adhered to airb
culates, and therefore, is not collected on the filter medi

4. The geometry factor (g) is 0.43 for both the alpha and b

5. The backscatter factor (bf) of 1.0 is used for the alp
which is determined from RaC'.

6. The sample absorption factor (sa) for RaC' is 0.77.

7. The window air factor (waf) for RaC' is 0.8.

8. RaB and RaC being beta emitters, are not counted in
mode.

9. The half-life of the radon progeny is approximately 3
based on the combined RaB and RaC half-lives.

10. No long-lived alpha emitters are present as evidenced b
count.

11. For all practical purposes, RaC' decays at the rate o
posite of RaB and RaC which is approximately 36 minutes

I. Equations Used to Derive Air Concentrations

$$A_o = \frac{A}{e^{-\lambda t}}$$

Where: A_o = Activity present at the end of the sampling (dis/min)

A = Activity at some time interval, after end of sampling (dis/min)

t = Time interval from end of sampling period to counting interval

$$\lambda = \frac{0.693}{t_{\frac{1}{2}}}$$

$t_{\frac{1}{2}}$ = Half-life of isotope (min)

$$C = \frac{A_o \lambda}{f} \cdot \frac{1}{(1-e^{-\lambda t_s})}$$

Where: C = Concentration (dis/min-m^3)

A_o = Activity on filter media at end of sampling period (dis/min)

f = Sampling rate (m^3/min = m^3/h · 1h/60min)

t_s = Length of sampling time (min)

$$\lambda = \frac{0.693}{t_{\frac{1}{2}}}$$

$t_{\frac{1}{2}}$ = Half-life of isotope or controlling parent (min)

Example Calculation - No.1 as given in Table 5.

$$A_o = \frac{15 \text{ dis/min}}{\exp \frac{-0.693 \cdot 100 \text{ min}}{36 \text{ min}}} = 102.8 \text{ dis/min}$$

$$C = \frac{102.8 \text{ dis/min} \cdot \frac{0.693}{36 \text{ min}}}{15/60 \text{ m}^3/\text{min}} \quad \frac{1}{1-\exp \frac{-0.693 \cdot 40 \text{ min}}{36 \text{ min}}}$$

$$= 14.7 \text{ dis/min-m}^3 \cdot 2 = 29 \text{ dis/min-m}^3$$

SOIL ANALYSIS PROCEDURE FOR TOTAL URANIUM AND GAMMA-EMITTING NUCLIDES

mary of Methods

A 60 milliliter volume of the received soil was counted in a petri di
inutes on a Ge(Li) detector over the energy range 0 - 1.5 MeV.
sponded to between 60 to 100 g of soil, depending upon bulk soil d
ve photopeaks above instrument background were converted to c
a line efficiency curve based upon a National Bureau of Standards
a standard. The natural Thorium-232 (^{232}Th) and Radium-226 (
chains were calculated using the 0.910 MeV Actinium-228 (^{228}A
MeV Bismuth-214 (^{214}Bi) photopeaks respectively. Cesium-
ted for each sample as a representative gamma emitter. Potass
was observed on all soil samples, as expected, but was not calc
ported.

ne gram of the soil sample was ashed and dissolved in HF-HNO_3 f
uranium analysis. A 100-λ aliquot of the dissolved sample was
98% NaF-2% LiF and the fluorescence determined using a Jarre
meter. A quenching factor was determined for each sample by us
al spike.

Radioactive half-lives of ^{234}U, ^{235}U and ^{238}U, as well as the ndance for each isotope were obtained as current best values f ble of Isotopes" - 6th Edition" by C. M. Lederer, J. M. Hollar erlman, 1967. The following values used are:

Isotope	Half-life (years)	Abundance
^{234}U	2.47×10^5	0.005
^{235}U	7.1×10^8	0.719
^{238}U	4.51×10^9	99.276
		100.001

It should be noted that the abundance totals 100.0013%. Since i determined which isotope(s) are in error, the calculations are m 0.0013% error not accounted for.

$$SpA = \lambda N = \frac{(\ln 2)\, N}{t_{\frac{1}{2}}}$$

SpA = Specific Activity

Avogadro's Number = 6.025×10^{23}

N = Number of radioactive atoms per unit mass

$$= \frac{\text{Avogadro's Number}}{\text{gram atomic weight}}$$

$t_{\frac{1}{2}}$ = Half-life in years (a)

$$SpA = \frac{0.693 \cdot 6.025 \times 10^{23}}{t_{\frac{1}{2}}\,(a) \cdot 5.256 \times 10^5 \frac{\text{min}}{\text{a}} \cdot \text{gram atomic weight}} = \text{dis/min-gram}$$

$$SpA\ ^{234}U = \frac{0.693 \cdot 6.025 \times 10^{23}}{2.47 \times 10^5 \cdot 5.256 \times 10^5 \cdot 2.34 \times 10^2}$$

$$= 1.374 \times 10^{10} \text{ dis/min-gram}$$

$$= 1.374 \times 10^4 \text{ dis/min-}\mu\text{gram} \cdot 5.70 \times 10^{-5}$$

$= 4.76 \times 10^{-3}$ dis/min-gram

$= 4.76$ dis/min-μgram $\cdot 7.196 \times 10^{-3}$

$= 0.034$ dis/min-μgram of natural uranium

$$\text{SpA } ^{238}U = \frac{0.693 \cdot 6.025 \times 10^{23}}{4.51 \times 10^{9} \cdot 5.256 \times 10^{5} \cdot 2.38 \times 10^{2}}$$

$= 7.4 \times 10^{5}$ dis/min-gram

$= 0.74$ dis/min-μgram $\cdot 9.9276 \times 10^{-1}$

$= 0.735$ dis/min-μgram of natural uranium

Therefore, the activity of 1 μgram of natural uranium is

0.783 dis/min ^{234}U + 0.034 dis/min ^{235}U + 0.735 dis/min

$= 1.552$ dis/min-μgram

$= \frac{1.552 \text{ dis/min-μgram}}{2.22 \text{ dis/min-pCi}}$

$= 0.6991$ pCi/μgram natural uranium

Conversion of μg/g to pCi/g

Example Calculation - 1-S2-A as given in Table 7.

$$[1.9 \pm 0.4] \frac{\mu\text{gram}}{\text{gram}} \cdot \frac{0.6991 \text{ pCi}}{\text{gram}} = [1.3 \pm 0.3] \frac{\text{pCi}}{\text{gram}}$$

APPENDIX 5

PERTINENT RADIOLOGICAL REGULATIONS, STANDARDS AND GUIDELINES

Excerpts From

DRAFT AMERICAN NATIONAL STANDARD

N13.12

Control of Radioactive Surface Contamination on Materials, Equipment, and Facilities to be Released for Uncontrolled Use

potentially contaminated surfaces are not accessible for measurement (
ne pipes, drains, and ductwork), such property shall not be releas
ant to this standard, but shall be made the subject of case-by-ca
tion.

rty shall not be released for uncontrolled use unless measurements sh
tal and removable contamination levels to be no greater than the valu
ble 1 or Table 2. (The values in Table 2 are easier to apply when t
inants cannot be individually identified.)

gs used to cover the contamination shall not be considered a solution
ontamination problem. That is, the monitoring techniques shall
ent to determine, and such determination shall be made, that the to
t of contamination present on and under any coating does not exce
able 1 or Table 2 values before release.

TABLE 1
SURFACE CONTAMINATION LIMITS*

Contaminants		Limit (Acti (dis/min-100	
scription	Nuclides (Note 1)	Removable	T (Fixe Rem
for which the pational MPC$_a$ is 2x10^{-13} Ci/m^3 for which ccupational MPC$_w$ is 2x10^{-7} Ci/m^3 or	^{227}Ac ^{241,242m,243}Am ^{249,250,251,252}Cf ^{243,244,245,246,247,248}Cm ^{125,129}I ^{237}Np ^{231}Pa ^{210}Pb ^{238,239,240,242,244}Pu ^{226,228}Ra ^{228,230}Th	20	Non (
clides not in for which the non- nal MPC$_a$ (Note 2) Ci/m^3 or less or the non-occupational ote 4) is 1x10^{-6} Ci/m^3	^{254}Es ^{256}Fm ^{126,131,133}I ^{210}Po ^{223}Ra ^{90}Sr ^{232}	200	Non

ity in any area of 100 cm^2 is less than three times the limit value.
oses of averaging with regard to isolated spots of activity, any s
r of surface shall be considered to be contaminated above the lim
cable to 100 cm^2, if (1) from measurements of a representative nu
sections it is determined that $1/\eta \sum_{i}^{n} S_i > L$, where S_i is the dis
cm^2 determined from measurement of section i; or (2) it is deter
the activity of all isolated spots or particles in any area less tha
exceeds 3L.

tegrations per minute per square decimeter.

S:
Values presented here are obtained from the Code of Federal Re
Title 10, Part 20, April 30, 1975. The most limiting of all given
s (for example, soluble versus insoluble) are to be used. In the
e occurrence of mixtures of radionuclides, the fraction contribute
constituent of its own limit shall be determined and the sum o
ons shall be less than 1.

Maximum permissible concentration in air applicable to contin
ure of members of the public as published by or derived fro
ritative source such as the National Committee on Radiation Prote
Measurements (NCRP), the International Commission on Radiol
ction (ICRP), or the Nuclear Regulatory Commission (NRC). Fro
of Federal Regulations, Title 10, Part 20, Appendix B, Table 2, C

The instrument utilized for this measurement shall be calibrate
re at least 100 pCi of any Group-1 contaminants uniformly spread
m^2.

Maximum permissible concentration in water applicable to members o
.

The instrument utilized for this measurement shall be calibrate
re at least 1 nCi of any Group-2 beta or gamma contaminants unif
d over an area equivalent to the sensitive area of the detector. D
y for unconditional release should be performed in areas where
round is < 100 counts per minute. When the survey must be perfo
background exceeding 100 counts per minute, it may be necessary t
ndirect survey method to provide the additional sensitivity requ

TABLE 2

ALTERNATE SURFACE CONTAMINATION LIMITS

(all Alpha Emitters, except U nat and Th nat, Considered as a Gro

	Limit (Activity) (dis/min-100 cm^2) +	
ination Contigencies	Removable	(F Re
contaminant cannot be identified; alpha emitters other than U nat e 1) and Th nat are present; or e beta emitters comprise ^{227}Ac ^{8}Ra	20	No
known that all alpha emitters generated from U nat (Note 1) Th nat; and if beta emitters present that, while not identified, ot include ^{227}Ac, ^{125}I, ^{226}Ra, and a	200	N
known that alpha emitters generated only from U nat e 1) and Th nat in equilibrium	1 000	

ALTERNATE SURFACE CONTAMINATION LIMITS
(cont'd)

e levels may be averaged over one square meter provided the max
vity in any area of 100 cm^2 is less than three times the limit value.
poses of averaging with regard to isolated spots of activity, any so
er of surface shall be considered to be contaminated above the lim
licable to 100 cm^2, if (1) from measurements of a representative numb
sections it is determined that $1/\eta \sum_{i=1}^{n} S_i > L$, where S_i is the dis/mi
determined from measurement of section i; or (2) it is determined
activity of all isolated spots or particles in any area less than 100
eeds 3L.

sintegrations per minute per square decimeter.

TES:

(1) U nat and decay products.

(2) The instrument utilized for this measurement shall be calibrate
sure at least 100 pCi of any Group-1 contaminants uniformly spread
cm^2.

(3) The instrument utilized for this measurement shall be calibrat
sure at least 1 nCi of any Group-2 beta or gamma contaminants unif
ead over an area equivalent to the sensitive area of the detector. D
vey for unconditional release should be performed in areas where
kground is < 100 counts per minute. When the survey must be perfo
background exceeding 100 counts per minute, it may be necessary t
indirect survey method to provide the additional sensitivity requ

GUIDELINES FOR DECONTAMINATION OF FACILITIES AND EQ

PRIOR TO RELEASE FOR UNRESTRICTED USE

OR TERMINATION OF LICENSES FOR BY-PRODUCT, SOURC

OR SPECIAL NUCLEAR MATERIAL

U. S. Nuclear Regulatory Commission
Division of Fuel Cycle and
Material Safety
Washington, D.C. 20555

November 1976

ne instructions in this guide in conjunction with Table I sp
dioactivity and radiation exposure rate limits which should be
complishing the decontamination and survey of surfaces or pre
quipment prior to abandonment or release for unrestricted use.
Table I do not apply to premises, equipment, or scrap containin
dioactivity for which the radiological considerations pertinent to
ay be different. The release of such facilities or items from
ntrol will be considered on a case-by-case basis.

1. The licensee shall make a reasonable effort to eliminate residual contamination.

2. Radioactivity on equipment or surfaces shall not be covered by paint, plating, or other covering material unless contamination levels, as determined by a survey and documented, are below the limits specified in Table I prior to applying the covering A reasonable effort must be made to minimize the contamination prior to use of any covering.

3. The radioactivity on the interior surfaces of pipes, drain lines, duct work shall be determined by making measurements at all traps, and other appropriate access points, provided that contamination at these locations is likely to be representative of contamination on the interior of the pipes, drain lines, or duct work. Surfaces of premises, equipment, or scrap which are likely to be contaminated but are of such size, construction, or location as to make the surface inaccessible for purposes of measurement shall be presumed to be contaminated in excess of the limits.

4. Upon request, the Commission may authorize a licensee to relinquish possession or control of premises, equipment, or scrap having surfaces contaminated with materials in excess of the limits specified. This may include, but would not be limited to, special circumstances such as razing of buildings, transfer of premises to another organization continuing work with radioactive materials, or conversion of facilities to a long-term storage or standby status. Such request must:

b. Provide a detailed health and safety analysis which reflects that the residual amounts of materials on surface areas, together with other considerations such as prospective use of the premises, equipment or scrap, are unlikely to result in an unreasonable risk to the health and safety of the public.

5. Prior to release of premises for unrestricted use, the licensee shall make a comprehensive radiation survey which establishes that contamination is within the limits specified in Table 1. A copy of the survey report shall be filed with the Division of Fuel Cycle and Material Safety, USNRC, Washington, D.C. 20555, and also the Director of the Regional Office of the Office of Inspection and Enforcement, USNRC, having jurisdiction. The report should be filed at least 30 days prior to the planned date of abandonment. The survey report shall:

a. Identify the premises.

b. Show that reasonable effort has been made to eliminate residual contamination.

c. Describe the scope of the survey and general procedures followed.

d. State the findings of the survey in units specified in the instruction.

review of the report, the NRC will consider visiting the facilities to he survey.

APPENDIX 5
(cont'd)

TABLE 1

ACCEPTABLE SURFACE CONTAMINATION LEVELS

)ES[a]	AVERAGE[bcf]	MAXIMUM[bdf]	REMOVAE
35, U-238, ıted decay	5 000 dis/min α-100 cm²	15 000 dis/min α-100 cm²	1 000 dis/m
cs, Ra-226 ı-230, Th-228, -227, I-125,	100 dis/min-100 cm²	300 dis/min-100 cm²	20 dis/mi
ı-232, Sr-90 ı-224, U-232, 1, I-133	1 000 dis/min-100 cm²	3 000 dis/min-100 cm²	200 dis/m
a emitters with decay modes alpha emission eous fission) 90 and others re.	5 000 dis/min βγ-100 cm²	15 000 dis/min βγ-100 cm²	1 000 dis/m

The maximum contamination level applies to an area of not more tha

The amount of removable radioactive material per 100 cm^2 of sur
that area with dry filter or soft absorbent paper, applying moder
radioactive material on the wipe with an appropriate instrument of
ination on objects of less surface area is determined, the pertine
and the entire surface should be wiped.

The average and maximum radiation levels associated with surfac
emitters should not exceed 0.2 mrad/h at 1 cm and 1.0 mrad/h at
more than 7 milligrams per square centimeter of total absorber.

APPENDIX 6

SURGEON GENERAL'S GUIDELINES

Part 712

Grand Junction Remedial Action Criteria

Federal Register, Vol.41, No.253, pp. 56777
Thursday, December 30, 1976

PART 712 GRAND JUNCTION REMEDIAL ACTION CRITERIA

Purpose.

(a) The regulations in this part establish the criteria for determ
ERDA of the need for, priority of and selection of appropriate r
n to limit the exposure of individuals in the area of Grand Ju
, to radiation emanating from uranium mill tailing which have bee
nstruction-related material.

(b) The regulations in this part are issued pursuant to Pub. L.
tat. 222) of June 16, 1972.

Scope.

The regulations in this part apply to all structures in the area of
ion, Colo., under or adjacent to which uranium mill tailings hav
as a construction-related material between January 1, 1951, an
972, inclusive.

Definitions.

As used in this part:

(a) "Administrator" means the Administrator of Energy Resear
opment or his duly authorized representative.

(b) "Area of Grand Junction, Colo.," means Mesa County, Colo.

(c) "Background" means radiation arising from cosmic rays and

(d) "ERDA" means the U.S. Energy Research and Develo
inistration or any duly authorized representative thereof.

(e) "Construction-related material" means any material used i
truction of a structure.

(f) "External gamma radiation level" means the average gamma rad
osure rate for the habitable area of a structure as measured near
.

(g) "Indoor radon daughter concentration level" means that concen
radon daughters determined by: (1) Averaging the results of 6 air s
of at least 100 hours duration, and taken at a minimum of 4
rvals throughout the year in a habitable area of a structure, o
zing some other procedure approved by the Commission.

(h) "Milliroentgen" (mR) means a unit equal to one-thousandth (1/
roentgen which roentgen is defined as an exposure dose of X or
ation such that the associated corpuscular emission per 0.001293 gr
produces, in air, ions carrying one electrostatic unit of quantity of
ty of either sign.

(i) "Radiation" means the electromagnetic energy (gamma) and
iculate radiation (alpha and beta) which emanate from the radio
y of radium and its daughter products.

(j) "Radon daughters" means the consecutive decay produc
n-222. Generally, these include Radium A (polonium-218), Radi

(k) "Remedial action" means any action taken with a rea
ctation of reducing the radiation exposure resulting from urani
gs which have been used as construction-related material in and
ctures in the area of Grand Junction, Colo.

(l) "Surgeon General's guidelines" means radiation guidelines rel
ium mill tailings prepared and released by the Office of the U.S. S
ral, Department of Health, Education and Welfare on July 27

(m) "Uranium mill tailings" means tailings from a uranium milling
involved in the Federal uranium procurement program.

(n) "Working Level" (WL) means any combination of short-lived
hter products in 1 liter of air that will result in the ultimate emi
$\times 10^5$ MeV of potential alpha energy.

1 Interpretations.

Except as specifically authorized by the Administrator in writ
rpretation of the meaning of the regulations in this part by an of
oyee of ERDA other than a written interpretation by the General
be recognized to be binding upon ERDA.

5 Communications.

Except where otherwise specified in this part, all commun
erning the regulations in this part should be addressed to the D
sion of Safety, Standards, and Compliance, U.S. Energy Resea
elopment Administration, Washington, D.C. 20545.

6 General radiation exposure level criteria for remedial action.

The basis for undertaking remedial action shall be the a
delines published by the Surgeon General of the United States
delines recommend the following graded action levels for remedial
ms of external gamma radiation level (EGR) and indoor radon
centration level (RDC) above background found within
structed on or with uranium mill tailings:

EGR	RDC	Recommendati
eater than 0.1 mR/h	Greater than 0.05 WL	Remedial action indicated
m 0.05 to 0.1 mR/h	From 0.01 to 0.05 WL	Remedial action may be suggested
s than 0.05 mR/h	Less than 0.01 WL	No remedial action indicated

.7 Criteria for determination of possible need for remedial action.

Once it is determined that a possible need for remedial action ex
ord owner of a structure shall be notified of that structure's eligi
engineering assessment to confirm the need for remedial actio
ertain the most appropriate remedial measure, if any. A determi
ssible need will be made if as a result of the presence of uranium

(a) Where ERDA approved data on indoor radon daughter conce
ls are available:

(1) For dwellings and schoolrooms: An indoor radon d
centration level of 0.01 WL or greater above background.

(2) For other structures: An indoor radon daughter concentrati
.03 WL or greater above background.

(b) Where ERDA approved data on indoor radon daughter conce
ls are not available:

(1) For dwellings and schoolrooms:

(i) An external gamma radiation level of 0.05 mR/h or greate
kground.

(ii) An indoor radon daughter concentration level of 0.01 WL or
ve background (presumed).

(A) It may be presumed that if the external gamma radiation
al to or exceeds 0.02 mR/h above background, the indoor radon c
centration level equals or exceeds 0.01 WL above background.

(B) It should be presumed that if the external gamma radiation
than 0.001 mR/h above background, the indoor radon c
centration level is less than 0.01 WL above background, and no
l for remedial action exists.

(C) If the external gamma radiation level is equal to or grea
1 mR/h above background but is less than 0.02 mR/h above back

(2) For other structures:

(i) An external gamma radiation level of 0.15 mR/h above back
veraged on a room-by-room basis.

(ii) No presumptions shall be made on the external gamma ra
vel/indoor radon daughter concentration level relationship. Decisio
e made in individual cases based upon the results of actual measure

2.8 Determination of possible need for remedial action where criteria have not been met.

The possible need for remedial action may be determined whe
iteria in 712.7 have not been met if various other factors are pr
uch factors include, but are not necessarily limited to, size of the a
ea, distribution of radiation levels in the affected area, amount of ta
e of individuals occupying affected area, occupancy time, and use
fected area.

2.9 Factors to be considered in determination of order of priority for remedial action.

In determining the order or priority for execution of remedial
nsideration shall be given, but not necessarily limited to, the fo
ctors:

(a) Classification of structure. Dwellings and schools sh
nsidered first.

(b) Availability of data. Those structures for which data on

(c) Order of application. Insofar as feasible remedial action
n in the order in which the application is received.

(d) Magnitude of radiation level. In general, those structures w
est radiation levels will be given primary consideration.

(e) Geographical location of structures. A group of structures
the same immediate geographical vicinity may be given
ideration particularly where they involve similar remedial efforts.

(f) Availability of structures. An attempt will be made to s
edial action during those periods when remedial action can be take
mum interference.

(g) Climatic conditions. Climatic conditions or other sea
iderations may affect the scheduling of certain remedial measures.

10 Selection of appropriate remedial action.

(a) Tailings will be removed from those structures whe
opriately averaged external gamma radiation level is equal to or
0.05 mR/h above background in the case of dwellings and scho
mR/h above background in the case of other structures.

(b) Where the criterion in paragraph (a) of this section is n
r remedial action techniques, including but not limited to s
ilation, and shielding may be considered in addition to that of
val. ERDA shall select the remedial action technique or combina
niques, which it determines to be the most appropriate und